PMT HV Dividers for NPS/CPS

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1. **Divider Status**
2. **Updated Specifications**
3. **Next Steps**

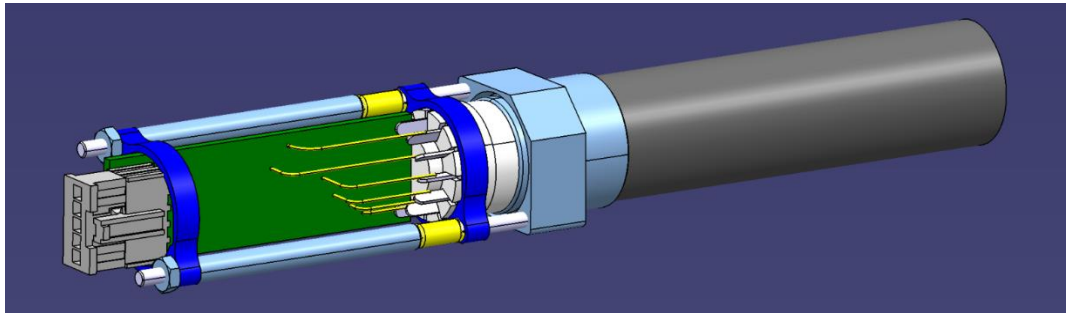
1. Divider Status

Crystal

PMT

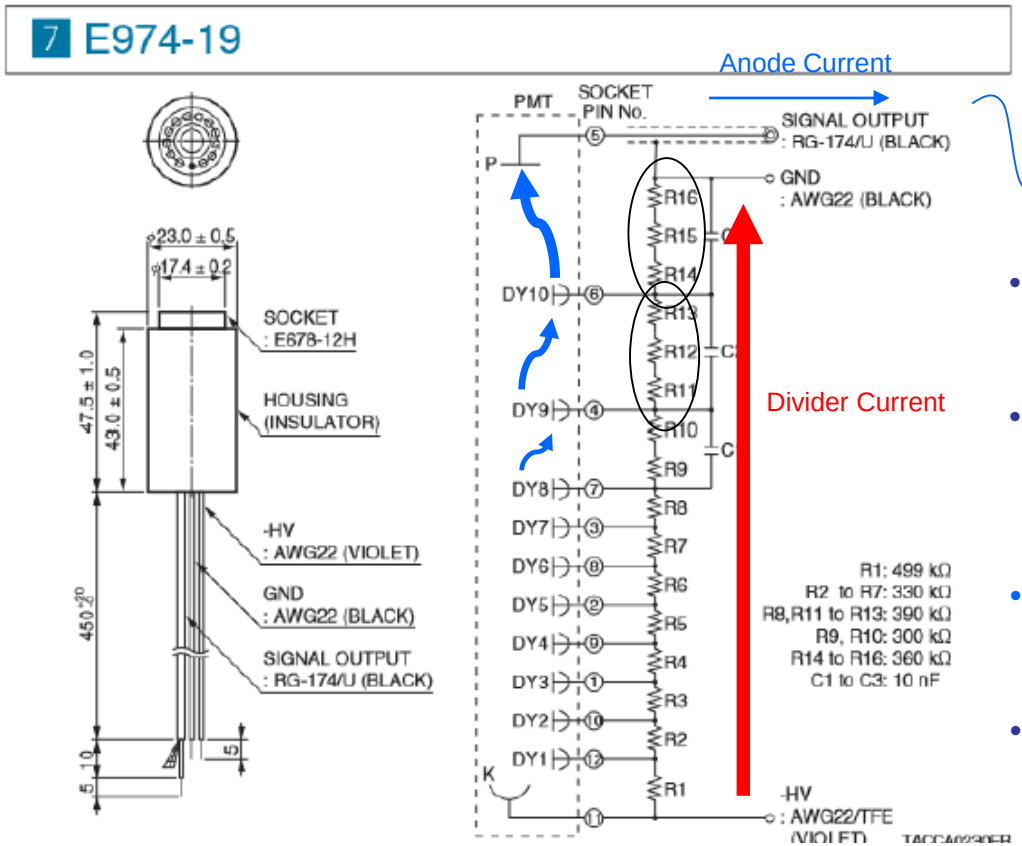
New HV Divider (Active)

- # Channels: 1156.
- PMT: Hamamatsu R4125 PMT (10 stages)
  - Nominal Anode Current (max) = 100 uA
  - Pulse Linearity = ± 2%
  - Gain = 10^5 @ 1.1 kV.
- HV Divider:
  - Active.
  - Based on an earlier design by V. Popov, H. Mkrtchyan (2012).
  - Updated design for reliability, component and production optimization.
  - Production complete with spares.



NPS PMT & Divider Assembly
(E. Rindel, IPNO, 1/31/2019)

Hamamatsu R4125 PMT Passive HV Divider



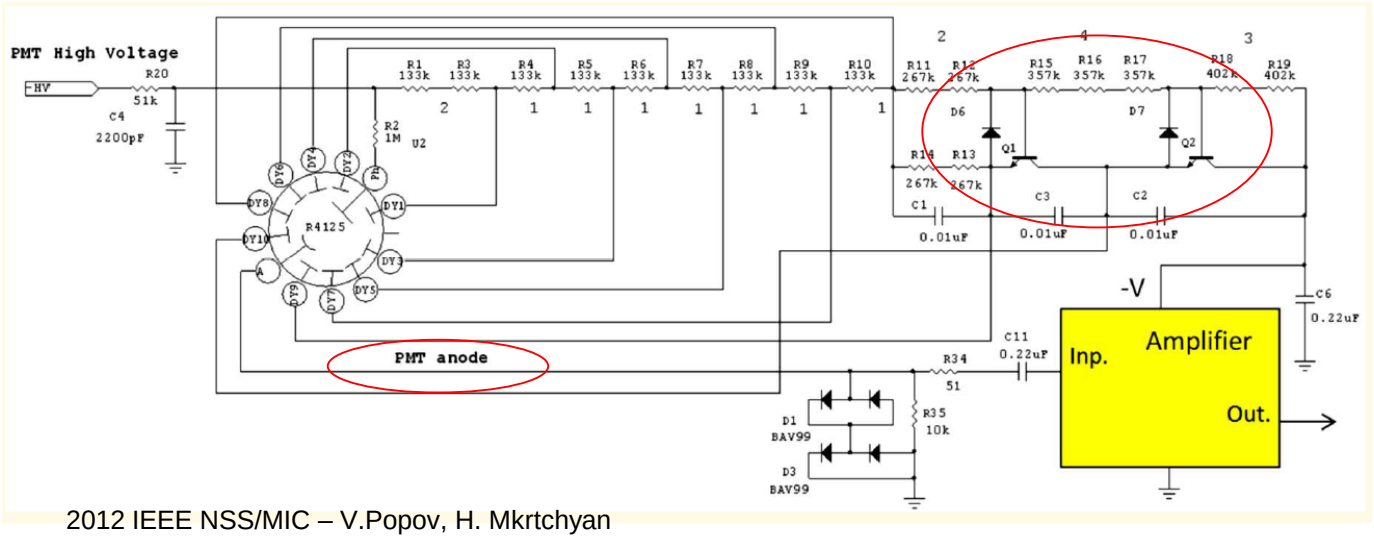
- ***For improved linearity, divider current >> average anode current.***
- ***Installing transistor regulation on the last two dynodes improves performance at high rates.***
- ***Good linearity in COMCAL at a few % with low preamp gain.***
- ***Ratios below result in half the PMT gain for the active divider.***

Table 2: Measured divider ratios

	K–Dy1	Dy1-Dy2	Dy2-Dy3	Dy3-Dy4	Dy4-Dy5	Dy5-Dy6	Dy6-Dy7	Dy7-Dy8	Dy8-Dy9	Dy9-Dy10	Dy10-GND
Active	1.8	1	1	1	1	1	1	1	2	4.3	3.5
Hamamatsu	1.4	1	1	1	1	1	1	1.2	1.8	3.3	3.1

Active HV Divider

- *Regulation on the last two dynodes provides for excellent stability and linearity at high rates, large dynamic range.*
- *Operating the PMT at lower gain → lower anode current → longer PMT life.*



2012 IEEE NSS/MIC – V.Popov, H. Mkrtchyan

Dynode Regulation

- *Zener Regulated*
- *CB Input*
- *PNP-NPN Driver*
- *Shaper*
- *Gain – set by 1 resistor*

- *Preamp is powered from HV supply, eliminating LV supply, connectors, controls, etc.*
  - *Divider Current: 430 uA (Active) vs. 170 uA (Hamamatsu passive).*
  - *Divider Ratios & Anode Current: Active = 1/2 Passive.*
  - *Preamp Gain ~ x25.*
- **Goal: decrease anode Current, attain good linearity.**

Observations from Bench and COMCAL tests:

- **fADC250 has three amplitude scales: 0.5 V, 1 V, 2 V.**
- **Non-linearity increases with decreasing amplitude scale for x3 preamp, likely a result of noise.**
- **Higher rate capability with lower gain.**
- **Estimate ~ 1/3 anode current of Hamamatsu passive divider with preamp (x3) and 2 V scale.**
- **Improved linearity with higher divider current:**
  - **~ 2% non-linearity**
  - **HV = 850 V, 800 uA**
  - **PMT gain ~ 10^4 range.**

2. Updated Specifications

Recommendations by Bogan Wojtsekhowski:

Anode current considerations

- Actual anode current with the current HV base is too high. The current inside PMT need to be reduced by a factor of 500-1000.

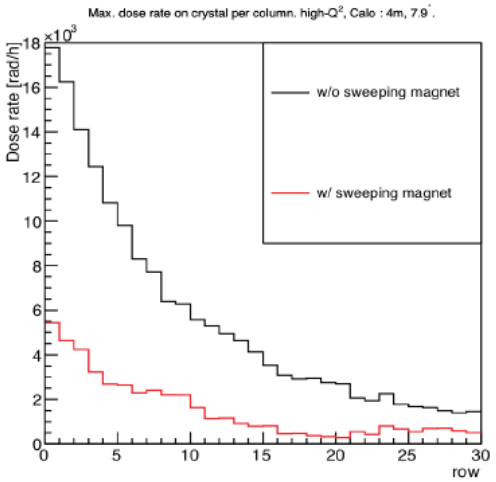
0.1 rad/s => 10^{-6} J/s/g => 10^{-4} J/crystal
⇒ 10^{15} eV/s => 10^{6} GeV/s

signal has 15 ph.e./MeV for NPS scintillator

⇒ 1.5 10^{10} ph.e./s in PMT gain of 10^{5}

⇒ average anode current = 250 uA

It is 2 times exceed the specs of R4125



- ***Lower anode current by a factor 500 – 1000:***
  - ***0.25 – 0.5 uA.***
- ***Lower PMT gain by shorting last few dynodes to anode.***
  - **10^3**
- ***Consider External Amp.***
- ***Noise may be an issue.***

- AC variation between blocks could be reduced by using a filter on PMT.

28/05/20 NPS meeting, May 28 6

3. Next Steps

- We would like to use the units that have already been produced and modify them accordingly.
- Two additional production dividers have been assembled and tested (Chris Stanislav) for further tests. Use one as reference and modify second as needed.
- Request that NPS personnel perform tests, We have the set up ready in EEL 118.
- Tests:
  - with production divider
  - increase divider current to ~ 800 uA for improved linearity
  - decrease PMT gain by shorting dynodes.